ISSN 0097-8078, Water Resources, 2018, Vol. 45, No. 4, pp. 560–564. © Pleiades Publishing, Ltd., 2018.
Original Russian Text © M.N. Shamsiev, A.N. Zinnatullina, R.I. Ibyatov, 2018, published in Vodnye Resursy, 2018, Vol. 45, No. 4.

HYDROPHYSICAL PROCESSES

Studying the Process of Pollutant Transport by Water Flowing under a Dam with a Rabbet

M. N. Shamsiev[a], A. N. Zinnatullina[b,]*, and R. I. Ibyatov[b]

[a] *Institute of Mechanics and Engineering, Subdivision of FIC KazanSC of RAS, Kazan, 420111 Russia*
[b] *Kazan State Agrarian University Kazan, 420015 Russia*
**e-mail: zinnatullina-alsu@mail.ru*

Received December 19, 2015; in final form, October 24, 2016

Abstract—The process of pollutant transport by water flowing under a hydraulic structure is examined. The study is focused on the effect of the number of rabbet under the dam and their positions relative to its subsurface contour on the process of pollutant transport.

Keywords: hydraulic structure, rabbet, groundwater flow, pollution

DOI: 10.1134/S009780781804019X

INTRODUCTION

The intense development of economy requires the solution of an important problem of protection of water resources against pollution and salinization by hazardous substances, as well as prevention and prediction of pollutant input into natural water bodies. The development of measures for pollution prevention and control is based on the comprehensive monitoring and detail expertise of polluted lands and groundwater; the unification of some parameters and methods for removal of pollutants from soil, including the construction of computer mathematical models for determining the extent of pollution. The common mechanism of pollutant propagation in porous medium is its transport by groundwater flow, accompanied by hydrodynamic dispersion.

Groundwater pollution has been studied by many researchers with different depth. Mathematical models of solute transport were developed in [3, 4, 10, 12]. In [10, 12], the causes and physical aspects of groundwater pollution are considered, data on the existing mathematical models of groundwater pollution processes are given, and the ways of their realization are discussed.

In this study, the process of pollutant transport by groundwater under a hydroengineering structure is simulated by a numerical model and the effect of the number and location of rabbet on pollutant flow is examined. The hydroengineering structures of different purpose are constructed in different natural environments [5]. They are used to implement various water-management operations, to create reservoirs, to regulate water discharges and levels, etc. Some mathematical models of groundwater flow under hydroengineering structures are considered in [9, 11]. The processes of migration of solutes under hydroengineering structures are discussed in [1, 2, 6–8].

MATHEMATICAL MODEL

Solute transport in groundwater flowing under a hydroengineering structure with a complex subsurface contour (Fig. 1) can be described by a differential equation [8, 10]:

$$D_x \frac{\partial^2 c}{\partial x^2} + D_y \frac{\partial^2 c}{\partial y^2} - V_x \frac{\partial c}{\partial x} - V_y \frac{\partial c}{\partial y} = \sigma \frac{\partial c}{\partial t}, \quad (x, y) \in Z, \quad t \in (0, T], \tag{1}$$

with an initial

$$c(x, y, 0) = c(x, y) \tag{2}$$

and boundary conditions

$$c(x, y, t)\big|_{AB} = \lambda(x, t), \tag{3}$$

$$\left.\frac{\partial c}{\partial y}\right|_{CD} = 0 \ \left(\text{or } c(x, y, t)\big|_{CD} = \nu(x, t)\right), \tag{4}$$

$$\left.\frac{\partial c}{\partial n}\right|_{L_1} = \left.\frac{\partial c}{\partial n}\right|_{L_2} = 0, \tag{5}$$

here D_x and D_y are convective diffusion coefficients; σ is active porosity; Z is flow domain; AB and CD are the boundaries of the upper and lower pools, respectively; l_1 and l_2 are the depth and width of the rabbet, respectively; L_x and L_y are the length and depth of the flow domain (the depth of the flow domain is chosen such that its value does not introduce errors in problem solution); l_1 and l_2 are the depth and width of the rab-